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ROLE OF COLLEMBOLA IN ORGANIC MATTER DECOMPOSITION IN TECHNOGENIC SIBERIAN LANDSCAPES

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Successions of microarthropods during the decomposition of manure and leaf composts (Chernova, 1977), clover green matter (Uvarov, 1982), straw (Naglitsch, 1966; Atlavinyté, 1971), oak leaves (Malatesta et al., 1986) are well studied. However, there are only a few papers on the estimation of Collembolan role in breakdown of organic matter in technogenic landscapes (Dunger, 1968; Hutson, 1980). There are practically no investigations on root destruction by Collembola.

The aim of this study is to record the Collembolan communities colonizing the aboveground plant residues (in Kuznetsk coal mining region) or roots of dominant plants (in Kansk-Achinsk coal brown region). The method of nylon bags with 2 mm mash size placed in 5 cm depth under undisturbed plant cover was used. There was also a special experiment with naphthalene to estimate a Collembolan contribution in root decomposition at different soil depth with 5 replications in each determination.

In KR there were 2 experiments. In the first one aboveground plant debris was destructed in bags from 17.X.1981 to 13.V.1982 ("winter" breakdown). As soil from November to March was frozen, the decomposition period continued practically only 2 months. The experiment took place in mountain-taiga, forest-steppe and steppe zones where precipitation were 980, 511 and 369 mm a year respectively. Zonal undisturbed habitats were aspen-fir taiga, pine-birch forest and meadow steppe. An amount of plant residues in bags was 5-35 g in accordance with autumn quantity on 15x15 cm size

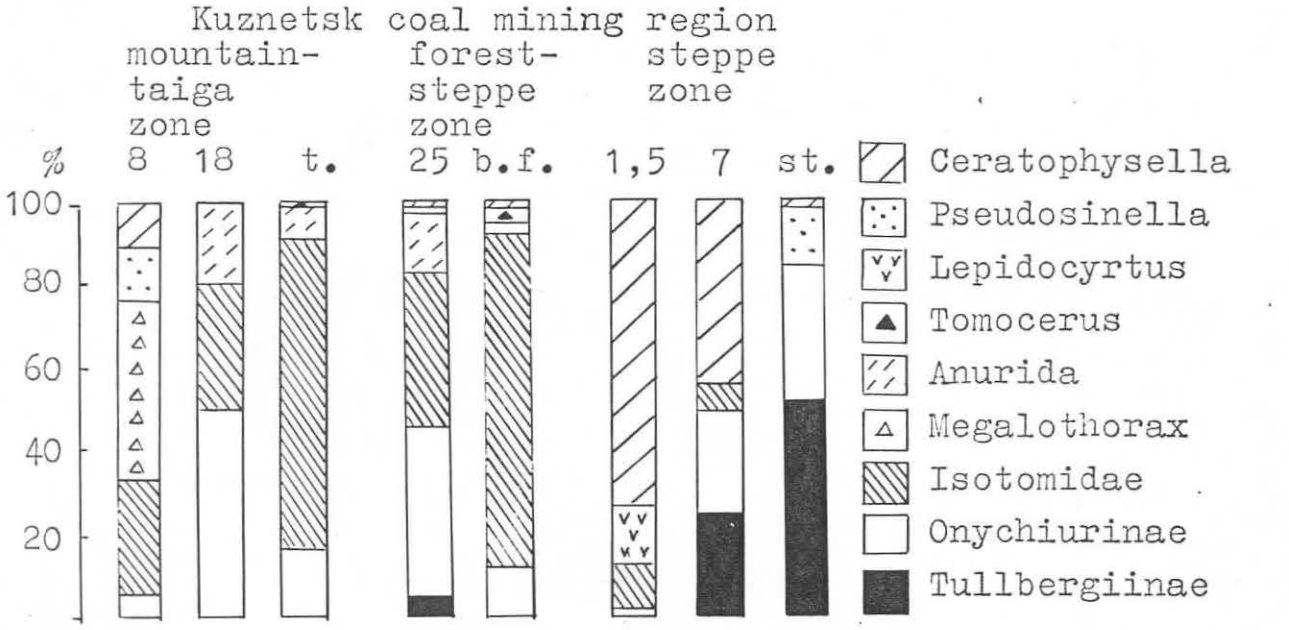

Fig. 1. Dominant Collembolan groups in bags after winter period of aboveground phytomass decomposition. Numbers - age of sites, t.-taiga, b.f.-pine-birch forest, st.-steppe.

plots. In the second experiment aboveground plant materials of cereals, leguminous plants and mixed ones were destroyed in separate bags during 2 summer months (VII-VIII.1982) in the pine-birch forest and 25 yr old spoil.

Fig. 1 shows that at 13.V.1982 after "winter" decomposition among destroyers Isotomidae were dominated in the zonal forestry habitats. Their share was up to 83% due to Folsomia quadrioculata, F. pseudodiplophthalma, Cryptopygus sphagneticolus as well as Isotoma notabilis and Heteroisotoma sp. in taiga. The rate of Onychiuridae (Paronychiurus, Protaphorura and Supraphorura species) was no more than 14,5%. In meadow steppe, on the contrary, Onychiuridae, especially Tullbergiinae (to 50%), predominated in litter bags. In xeroterm conditions of young spoils in steppe zone the share of Hypogastruridae due to Ceratophysella succinea was very high. It decreased with increasing the reclaimed site age. Among sparse Isotomidae there were Proisotoma species. In young recultivated sites Lepidocyrtidae were a usual group in bags but in 6-7 yr old sites with bushes of Hyppophaë rhamnoides the share of Tullbergiinae sharply in-

creased (up to 25%). This makes them similar to steppe in this respect. For xerotermic top spoils (5-8 yr old) in taiga zone Megalothorax minimus, I. notabilis, Folsomides parvulus, C. succinea and Pseudosinella gr. octopunctata were characteristic. In 18 yr old site in taiga zone, covered by Salix and Betula, Onychiuridae predominated among winter destroyers, but there were no Tullbergiinae although they recorded in this habitat in summer. Anurida (18,7%) and Isotomidae (Cr. sphagneticolus - 22%) were also found. In 25 yr old site in forest-steppe zone the shares of Onychiuridae, Isotomidae (I. notabilis - 31,5%, I. olivacea - 5,2%) and Anurida gr. ellipsoides were significant. On the whole Collembolan communities in litter bags even in old recultivated sites during winter decomposition greatly differed from zonal variants. This difference preserved during the summer decomposition but in 25 yr old site the share of Mesaphorura and I. olivacea increased, Anurida decreased to 0,1-0,5%, Tomoceridae appeared (Naplekova et al., 1985).

The rate of aboveground phytomass breakdown from November to May was approximately equal in both old sites and zonal habitats in taiga and forest-steppe zone (32-30%, 35-38%) and lower in steppe: 28,4% in spite of small sample (5 g) but the lowest in 1,5-7 yr old spoils (16,7-20,5%). For two summer months in forest-steppe zone of KR 70-75% of leguminous aboveground debris, 36-40% of cereals and 34-48% of mixed plant debris were destroyed (Naplekova et al., 1985).

In KAR the experiments with root destruction took place on levelled revegetated spoil during 1984-1988 years. In fact Collembolan composition depends on both the succession stage and substrate nutritiousness. In young weakly revegetated 2 yr old site after 300 days of decomposition Collembola prefered the fresh roots in comparison with a loam without roots and small humus-like roots. The lowest density and diversity (5-7 species) were recorded in two latter substrates, sharply increasing (up to 30-142 ind per g and 13-14 species) in fresh roots in row: Melilotus albus,

herbs, clover, cereals and wormwood. The share of Hypogastruridae was high in all roots. Moreover there were many Tullbergiinae in clover and cereal roots (Stebaeva et al., 1987).

The local phytogenic clusters of Collembola effect on communities in bags. In 3-4 yr old site during the summer decomposition (VII-VIII. 1986) of roots (Trifolium pratense, M. albus, Artemisia vulgare and cereals) in all root bags, which were destroyed in cereal plots, the complex Folsomia fimetaria - Mesaphorura krausbaueri dominated. On the plots with leguminous plants in 20 first days in bags Lepidocyrtinae - M. krausbaueri predominated and later - Hypogastruridae - M. krausbaueri. Isotomidae (in general Proisotoma minuta, P. minima) were not numerous. The increasing of density of Hypogastruridae by the 40th day both in bags and control soil under leguminous plants was synchronic according to the humidity increasing. The species variety was maximum at the start of root colonization: after 10 days -14-17 species, 40 days -12-13 ones, at 305 days - 11-13 species.

The mean Collembolan density for 5 experimental plots after 40 days of decomposition was highest in bags with leguminous roots (237-328 ind per g d.w.) and lowest - in cereal roots (104 ind per g). After 305 days the Collembolan density was no more than one at the start of root colonization. Isotomidae and Tullbergiinae predominated. The rate of Oribatei in bags was 3-17% during the first 40 days.

It is well known that roots of leguminous plants as well as their green mass (Uvarov, 1982) breakdown quicker than cereal roots (Aristovskaja, 1980). In our 1986-1987 yr experiment M. albus roots were destructed at 305 days to 63,5%, clover roots - 59,7%, wormwood ones - 51% and cereal roots - 36,3% (Stebaeva and Naumova, 1989). The breakdown rate had quick weight loss in the first 10 days (up to 19-32%). It is probably due to a high activity of microorganisms as it was shown before (Naplekova et al., 1985).

Another experiment with summer destruction (VII-VIII.

1988) of M. albus and cereal roots at different depth (5, 10 and 20 cm) and the bordering of some root bags by naphthalene took place in wet year on the same revegetated site (5 yr old now), but only on the sampling plot with monotonouse plant cover with M. albus 2 yr old. The mash size was 2 mm, bag size - 10x10 cm, initial root weight - 5 g. For placing bags in the soil a trench was dug. In its vertical undisturbed site a narrow longitudinal cuts for bags were made at 10 and 20 cm depth. After placing bags in the soil a trench was covered.

The roots in bags at 5 cm depth were colonized by Collembola intensively. Folsomia fimetaria was an absolute dominant, but the rate of colonization depended on root species. More soft cereal roots were colonized quickly. The maximum Collembolan density was recorded in it after 10 days (up to 711 ind per bag or 165,6 ind per g d.w.) decreasing to the 40^{th} day in 7 times. The larger and wooden-like roots of M. albus were colonized by Collembola gradually during fragmentation. Maximum mean density was found in 30 days (3053 ind per bag or 1282 ind per g d.w. of roots). F. fimetaria was 96% of the total number. This species is known to take part in straw and leaves destruction (Dunger, 1956; Atlavinyté, 1971). Among the other destructors Lepidocyrtus violaceus and M. krausbaueri were abundant enough. As a whole 13 species of Collembola took part in breakdown of roots. In comparison with previous years (1984-1987) the share of Hypogastruridae decreased to 0,3%, as well as Onychiuridae: Paronychiurus gr. granulosus, a pioner of colonization of this spoil, disappeared. Megalothorax minimus and Arrhopalites caecus were replaced by meadow species - Sphaeridia pumilis.

The species variety in bags at 5 cm depth was higher than in control soil nearby as well as in bags at 10-20 cm depth. The Collembolan abundance in control soil during experiment was low (15-49 ind per 125 cm^3). Isotomidae (Isotoma viridis) and M. krausbaueri dominated. The share of F. fimetaria in control soil was only 0,9-13,2%, i.e. con-

siderably lower than in root bags. The Collembolan density in root bags at 10-20 cm depth sharply decreased. It was not more than 90,7 and 28,0 ind per bag for M. albus or 114,0 and 23,0 ind per bag for cereal roots. There was no such violent breeding of F. fimetaria as at 5 cm depth. As a result the weight loss of M. albus roots at 10 and 20 cm depth was less than at 5 cm depth on 7% and 10,4% respectively. For cereal roots this difference was 10,8% and 11,2% (Fig.2) After 40 days the weight loss of M. albus roots at 5 cm depth was 58,2%, of cereal ones - 18,4%.

Only single individuals of 6 species penetrated into root bags, treated by naphthalene, S. pumilis and L. violaceus more often than others. The mean density of Collembola during 40 days was very low (1,4-5,2 ind per bag) thus, it can be neglected. The weight root loss due to pedobionts may be estimate by the difference in bags with and without naphthalene. Fig. 2 shows that during first 40 days microfauna destructed 17,7% of M. albus roots and about 6% of cereal ones at 5 cm depth (in average 11%). As a total quantity

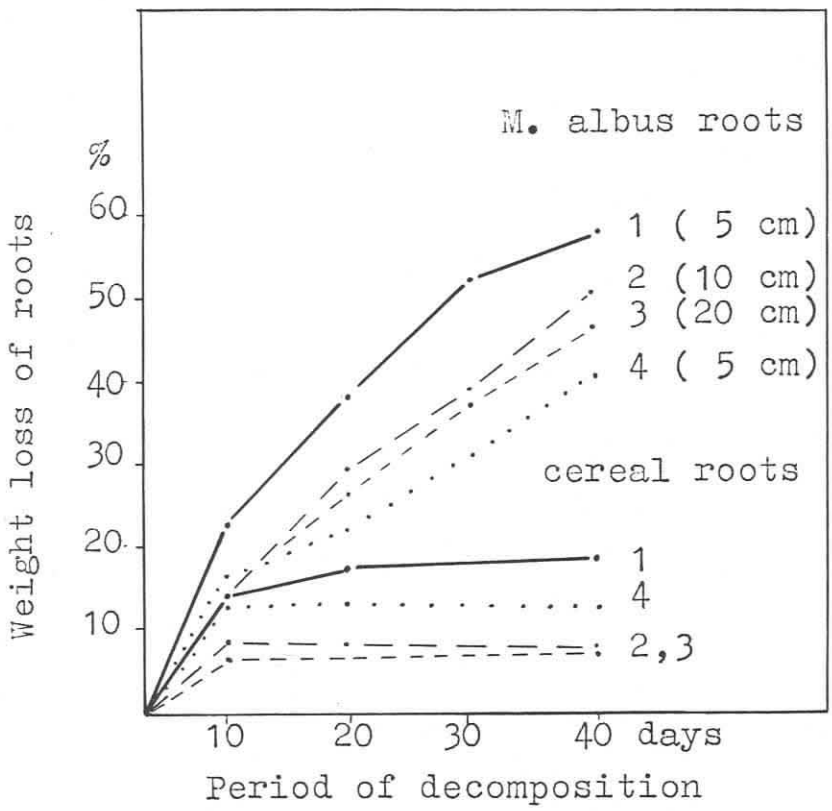

Fig. 2. The influence of depth and naphthalene application on weight loss of roots : 1, 2, 3 - without naphthalene, 4 - with naphthalene.

of dead roots in 0-10 cm layer was 544 g per m^2(Titlyanova and Mironycheva-Tokareva, personal communication) about 60g per m^2 of roots were destructed by microfauna during 40 summer days.

As preliminary sampling showed there were no Lumbricidae in this spoil. From other groups Nematoda , not calculated by me, might take part in root breakdown. Moreover a small Diptera larvae penetrated into bags. The Collembolan share in bags with M. albus roots (after 40 days at 5 cm depth) was 93,8% of the total number of saprophagous microarthropods (Oribatei - 2%) and cereal roots - 61,4% (Oribatei - 30,4%). It is obviously that Collembola (among microarthropods) played the main role in root decomposition. However at 10 or 20 cm depth where Collembolan number was low probably only microorganisms and small Diptera larvae destructed the roots. The cereal roots decomposed at depth especially slowly.

Thus in technogenic landscapes of Siberia Collembola take an active part in destruction of aboveground plant residues as well as root material, especially in upper soil layers. Their contribution to breakdown is very essential in the second stage of technogenic succession that agree with the data from other regions (Dunger, 1968; Hutson,1980) Complexes of destroyers depend on the age of reclamation sites, their position on catena, climatic conditions and the stage of the decomposition.

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